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ABSTRACT

Included are three Learning Activity Packages (LAP) studies for use in high school physics instruction: Time and Measurement Function; Force, Work, and Momentum; and Momentum, Work, and Energy. Each LAP contains a rationale for teaching the material included, student objectives (stated in behavioral terms), a list of resources (readings, problems, laboratory activities, audiovisual aids), a student self-evaluation, and suggestions for advanced study. (PEB)

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SE

LEARNING
ACTIVITY
PACKAGE

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TIME AND MEASUREMENT FUNCTION

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Previous math and science courses have taught you to use the concepts of time and measurement. You have learned to perform simple operations such as measuring the distance a moving body travels over a certain time interval.

This LAP will go beyond these elementary applications. It will enable you to measure movement using multiple flash photography and the stroboscope. Also, it will introduce you to the function, a mathematical tool that is used extensively in physics.

When you have successfully completed this LAP, you will be able to use these concepts to aid you in the study of linear and circular motion.

BEHAVIORAL OBJECTIVES:

After you have completed the prescribed course of study, you will be able to:

1. Use the concept of multiple flash photography to:
   a. determine the speed of an object moving in a straight line.
   b. determine the flash rate needed to restrict a given object's movement a certain amount during the flash.
   c. determine the flash rate needed to take pictures of a moving object at certain distance intervals.
2. Use the speed of a stroboscope to determine the speed of an object undergoing repetitive motion.
3. a. Express any given number in powers of ten (scientific) notation.
   b. Perform the four fundamental mathematical operations on any numbers expressed in powers of ten notation.
   c. Give the order of magnitude of any number expressed in powers of ten notation.
4. a. Give a one half page discussion of the method of triangulation.
   b. Measure distances using the method of triangulation.
   c. Give a one quarter page discussion of a procedure that uses the method of triangulation to find distances to "near" stars.
5. Give a one page discussion that gives two arguments to show our world is three dimensional.
6. Solve problems using the concept of significant digits.

I. Reading and Problems:

1. PSSC, Physics: pps. 7-37, exs. pps. 19-20, 8, 10-13, 16-18, 20, 24-30; exs. pps. 37-39, 6-7, 19-20, 23-25, 27-30.

2. Williams, Modern Physics: pps. 23-31, exs. A (5-8).

II. Laboratory

PSSC LAB Guide - Experiment 1-1.

1. A flash camera was set up to take pictures of a moving projectile. The shutter speed of the camera was [illegible]. If the projectile moved 5 m. between the two pictures, what was its speed? (Assume the speed remained constant)

2. A stroboscope is made up of four quarter sections: one clear, one opaque, one clear, and one opaque. A light is directed onto the stroboscope which is rotating at the rate of 50 revolutions per minute.

   a) What is the time interval from the end of one light impulse to the end of the next light pulse?

   b) What is the time interval from the end of one light pulse to the beginning of the next ?

3. Simplify the following:

   a) $3.2 \times 10^{-6} + 4.6 \times 10^{-5}$

   b) $7.4 \times 10^{3} \div 3.9 \times 10^{-8}$

   c) $2.1 \times 10^{5} \times 3.3 \times 10^{-4}$

4. Discuss the method of triangulation. In your discussion you should include a diagram and a sample problem illustrating the method of triangulation.

5. Present an argument that shows our world is three dimensional.

6. a. A person measures a rectangular solid and finds the length to be 5.3 m., the width to be 7.69 m. and the height to be 3.397 m. What is the volume of this rectangular solid?

b. The height and base of a triangle are 3.2 and 6.97 inches respectively. What is the area of the triangle?

IF YOU HAVE SUCCESSFULLY MASTERED THESE GOALS, A PROGRESS TEST IS SCHEDULED.

BEHAVIORAL OBJECTIVES:

After the completion of this section of study you will be able to:

7. Define:

   a. a direct proportion relation

   b. an inverse proportion relation

   c. a function

   d. the inverse square relation of light

   e. interpolation and extrapolation

   f. scaling

8. Use power laws and the concepts of similar figures to determine the dimensions of one geometric figure given the dimensions of a similar figure.

9. a. Find the distance from an object to a light given the intensity of the light and of another light whose distance from the object is known.

   b. Find the relative distances from two lights to an object between the lights, given the intensity of the lights and the total distance between the lights.

10. Determine in what proportion you must strengthen an object if you increase its linear dimensions and wish to maintain the same strength/weight ratio.

RESOURCES

I. Reading and Problems

1. PSSC, Physics: pps. 40-51, exs. 8-9, 11-12, 19-20, 24-25.

II. Laboratory (Consult your teacher).

1. Define:

   a) interpolation and extrapolation

   b) the inverse square relation of light

   c) a direct proportion relation

2. The volume of one cylinder is eight times the volume of another similar cylinder. If the circumference of the base of the smaller cylinder is 3 cm., what is the circumference of the base of the larger cylinder.

3. The distance between two street lamps is 60 m. Where should an observer stand between the lamps if he wants one lamp to be four times as intense as the other?

4. a. If you scale up all the linear dimensions of a rectangular solid by 9, how much do each of the following change?

   1) volume

   2) surface area

   b. A steel ball is hanging from a rope 7 cm. in diameter that just supports it. If you increase the volume of the ball 5 times, how much do you need to increase the diameter of the rope so it will continue to support the ball?

ADVANCED STUDY

1. Calculate the diameter of the moon. (Hint: See the exercises in your text).

REFERENCES

Textbooks

1. Physical Science Study Committee, Physics, 2nd edition (D. C. Heath and Company, 1965).

2. Williams, Metcalfe, Trinklein, Lefler, Modern Physics, 2nd Edition (Holt, Rinehart, and Winston, Inc., 1968).

Workbooks

1. Physical Science Study Committee, Laboratory Guide, Physics, 2nd Edition (D. C. Heath and Company, 1965)

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Learning Activity Package

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FORCE, WORK, and MOMENTUM

Ninety Six High School
Ninety Six, S.C.

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RATIONALE

So far in our study of Physics, we have been primarily interested in how a body moved rather than what makes it move. We have constructed elaborate graphs to show the displacement and velocity of a moving body and from these graphs, we have been able to calculate the velocity and the acceleration of the body. Nowhere did we take into consideration what makes an object move or what makes it stop moving.

In this LAP we will study what makes an object move and what makes it continue moving. From this we will go into an analysis of the motion of objects "near" the earth's surface and the various forces acting on such objects. Finally, we will go into an analysis of centripetal motion and its applications for the motion of satellites.

Section I

BEHAVIORAL OBJECTIVES:

By the completion of the prescribed course of study, you will be able to:

1. a) State Galileo's Law of Inertia.

   b) Give at least a one-half page explanation of the thought experiment that Galileo used to discover his law.

2. Demonstrate your understanding of the relationship between the mass of a body, the change in velocity of a body, the force acting on a body, and the time in which the force acts by being able to state an equation showing this relationship and being able to calculate the value of one of the variables given the value of the other three.

3. Demonstrate your understanding of the similarities of inertia and gravitational mass by writing a one-half page paper comparing and contrasting them (your paper should contain the definition of the two terms, properties they have in common, and properties they do not have in common).

4. Take several forces acting on a body and resolve them into the net force acting on the body.

I. Readings:

1. PSSC - Physics: #1 pps. 318-322; #2 pps. 323-325, pps. 328-329; #3 pps. 325-328; #4 pps. 329-331.
2. Taffel - Physics, Its Methods and Meanings: #1 pps. 102-103; #2 pps. 103-106; #3 pps. 107-108; #4 pps. 54-58.
3. Williams - Modern Physics: #1 pps. 85-86; #2 pps. 86-89; #3 _____; #4 _____.

II. Problems:

1. PSSC - Physics: #1 _____; #2 pps. 332-333 exs. 3, 6-10, 13-14, 16-22; #3 _____; #4 p. 333 exs. 25-31.
2. Taffel - Physics, Its Methods and Meanings: #1 _____; #2 pps. 111-113 exs. 1(1-4, 6-12), 1(1-2, 7-10, 12, 14-15); #3 _____; #4 p. 59 exs. 1(1, 3-4).
3. Williams, Modern Physics: #1 _____; #2 pps. 94-95 1-3, 6-7, 12; #3 _____; #4 _____.

III. Laboratories:

1. PSSC - Laboratory Guide, pps. 35-40.
2. Taffel - Laboratory Manual, Physics, Its Methods and Meanings, pps. 27-33, 53-57.

IV. Visual:

1. McGraw Hill Filmstrip - Force and Motion.

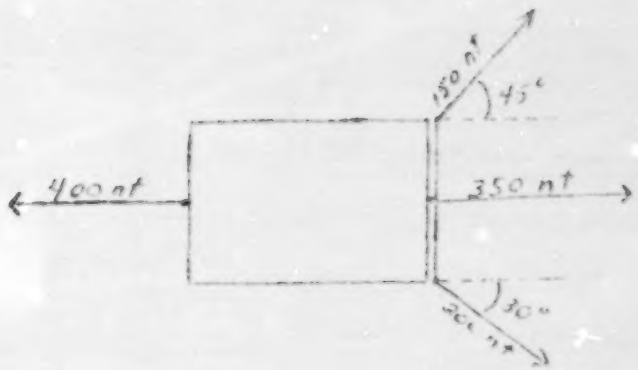
1. Discuss the thought experiment that Galileo used to discover his Law of Inertia.

2. a) A railroad engine of mass 12,000 kg is rolling along the tracks at a speed of 35 m/sec. The brakes are applied and the engine decelerates constantly and stops in 25 sec. What is the magnitude of the braking force and in what direction does it act?

   b) If an object with mass m is acted on by a certain force to give it an acceleration of 20 m/sec.^{2}, and if another object m_2 is acted on by a force four times as great to give it an acceleration of 15 m/sec.^{2}, what is the ratio of m_2 to m?

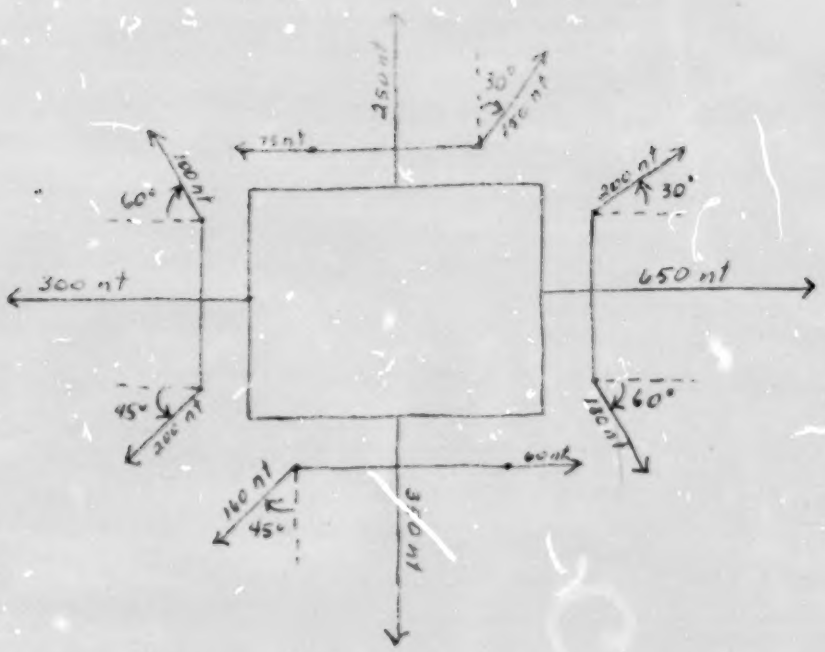
3. Discuss gravitational mass and inertial mass.

4. Consider the following diagram:



What is the net force acting on this object?

1. Consider the following diagram:



What is the resultant force acting on this object?

2. The retarding force of air resistance on a baloon is proportional to the square of the velocity. For a certain baloon, inflated a certain amount, this force is given in newtons by $F_r = .2V^2$ where V is the velocity in m/sec. The baloon and the air inside have a combined mass of 10 gm.
   a) Draw graphs of the baloons acceleration as a function of velocity when you pull it with a 1.8-newton force and 7.2-newton force.
   b) What is the maximum velocity that the baloon will reach in each case?
   c) If the mass were 5.0 gm., how would this affect the maximum velocity?
   d) What do you think would be the effect on the maximum velocity if you inflated the baloon to a larger volume?

Section II

BEHAVIORAL OBJECTIVES:

By the completion of the prescribed course of study, you will will be able to:

5. Demonstrate your understanding of the relationship between the mass of a body, the gravitational force acting on a body, the air resistance acting on a body, and the amount gravity accelerates a body by being able to state an equation showing this relationship and being able to calculate the value of one of the variables given the value of the other three.
6. Demonstrate your understanding of projectile motion by being able to take an object projected at a given angle and;
   a) determine the horizontal and vertical displacement of the object's velocity when it was projected and at any time thereafter.
   b) determine the horizontal and vertical displacement of the object in a given time interval.
   c) determine the time of travel of the projectile.
   d) draw a position time graph for the projectile's motion for a given time interval.
7. a) Derive a formula that will enable you to calculate the speed of an object moving in a circular path of radius R when the object's period of motion is T.
   b) Use the formula derived in part (a) to calculate the value of one of the variables if the other two are given.
8. a) Derive a formula for centripetal acceleration in terms of

(1) speed and period of motion, or

(2) speed and radius of the circle, or

(3) radius of the circle and period of motion.

b) Use the formulas derived in part (a) to calculate the value of one of the variables if the other two are given.

9. a) Derive a formula for centripetal force in terms of:

(1) speed and radius of the circle, or

(2) radius of the circle and period of motion.

b) Use the formulas derived in part (a) to find the value of one of the variables given the value of the other three.

RESOURCES

I. Readings:

1. PSSC - Physics: #5 pps. 335-336; #6 pps. 338-340; #7, 8, 9 pps. 340-347.
2. Taffel - Physics, Its Methods and Meaning: #5 pps. 77-79; #6 pps. 84-89; #7, 8, 9 pps 90-94.
3. Williams - Modern Physics: #5 ____; #6 pps. 102-103; #7, 8, 9 pps. 103-108.

II. Problems:

1. PSSC - Physics: #5 p. 354 exs. 1-2, 4, 7; #6 p. 354 exs. 8-15; #7, 8, 9 pps. 354-355 exs. 16-21, 24-25.
2. Taffel - Physics, Its Methods and Meanings: #5 ____; #6 pps. 84-89 exs. 1(1,3), 2(9), 1(4-9(, 2(16-19): #7, 8, 9 pps. 98-100 1(6), 2(10-12, 1(10-13), 2(20-22).
3. Williams, Modern Physics: #5 ____; #6 ____; #7, 8, 9 pps..111-112 exs. 1-7.

III. Laboratories:

1. PSSC - Laboratory Guide: pps. 41-45.
2. Taffel - Laboratory Manual, Physics, Its Methods and Meanings: pps. 67-70.

1. What is the air resistance acting on a body whose mass is 0.8 kg at a point on the earth where the acceleration of gravity is 9.81 m/sec.^{2} and the net force acting on the object is 6.8 nt?

2. An artillery piece is fired at an angle of 30° with the horizontal with a muzzle velocity of 120 m/sec.
   a) What are the X and Y coordinates of the shell after 1.2 sec.?
   b) How long will the shell be in the air (assume the muzzle of the gun is even with the ground).
   c) How far horizontally will the shell travel?
   d) Draw a position time graph for this shell from the time it was fired to the time it reached its apex.

3. If a proton moves in a circular orbit of radius 2×10^{-12} cm and goes $\frac{1}{4}$ of the way around the circle in .0005 sec., what is the speed of the proton?

4. a) Derive a formula for centripetal acceleration in terms of speed and period of motion.
   b) An object moves in a circular path with radius 7.3×10^{-2}m with a speed of 2.7×10^{4} m/sec. What is the centripetal acceleration of the object?

5. a) Derive a formula for centripetal force in terms of radius of the circle and period of motion.
   b) An object of mass .5kg moves around a circle of radius 10 m in .9 sec. What is the centripetal force acting on this object?

ADVANCED STUDY

1. If an airplane with a speed of 200 m/sec. is diving at an angle of 60° with the horizontal and releases a bomb and hits a target which is 1 km horizontally in front of him, what should the altitude of the plane be?

2. A mortar is fired at an angle of 30° with the horizontal and at an angle of 60° with the horizontal. The muzzle velocity both times was 300 m/sec. Determine whether the projectile traveled the same distance horizontally in both cases.

3. A cannon is situated on a cliff 500 m high pointing at an angle of 30° with the horizontal. It is has a muzzle velocity of 300 m/sec.,
   a) How long will the projectile remain in the air?
   b) How far horizontally will the projectile have traveled at the end of this time.
   c) Draw a position time graph for this projectiles motion.

4. A rifle is pointed upward at an angle of 45° with the horizontal and sighted on an object that is 350 m horizontally from the end of the rifle. Simultaneously, the rifle is fired and the object is dropped from rest. If the muzzle velocity of the rifle is 130 m/sec.,
   a) At what time will the bullet hit the object?
   b) What will be their vertical height at that time?

Section III

BEHAVIORAL OBJECTIVES

By the completion of the prescribed course of study, you will be able to:

10. a) Derive a formula that will enable you to determine the restoring force actin on an object that is undergoing simple harmonic motion.
    b) Use the formula derived in part (a) to calculate the value of one of the variables given the value of the other three.
11. a) Derive a formula that will enable you to determine the period of an object that is in simple harmonic motion.
    b) Use the formula derived in part (a) to calculate the value of one of the variables given the value of the other two.
12. a) Derive a formula that will enable you to determine the restoring force acting on the bob of a pendulum.
    b) Use the formula derived in part(a) to calculate the value of one of the variables given the value of the other two.
13. a) Derive a formula that will enable you to determine the period of a pendulum.
    b) Use the formula derived in part(a) to calculate the value of one of the variables given the value of the other two.
14. Give a detailed argument that will determine whether there is such a force as centrifugal force.

RESOURCES

I. Readings:

1. PSSC - Physics: #10, 11, 12, 13 pps. 347-350; #14 pps. 350-353.
2. Taffel - Physics, Its Methods and Meanings: #10, 11, 12, 13 pps. 94-97; #14 p. 122.
3. Williams, Modern Physics: #10, 11, 12, 13 pps. 119-122; #14 _____.

II. Problems:

1. PSSC - Physics: #10, 11, 12, 13 p. 355 exs. 26-32; #14 _____.
2. Taffel - Physics, Its Methods and Meanings: #10, 11, 12, 13 pps. 98-100 exs. 1(7-8), 2(13-14), 1(14-15), 2(24-25); #14 _____.
3. Williams - Modern Physics: #10, 11, 12, 13 ppsx 122-123 exs. A(1-4), B(6-10), A(1-2), B(4).

III. Laboratories:

1. Taffel - Laboratory Manual, Physics - Its Methods and Meanings: pps. 19-21, 41-44, 49-52.

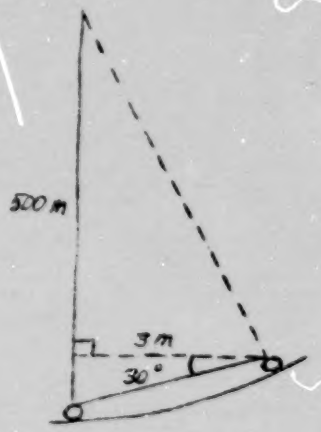
SELF-EVALUATION

1. If an object of mass 8 kg is undergoing simple harmonic motion and has a period of 1.8 sec., what will be the restoring force acting on the object if it is displaced 3 m from the origin?

2. Derive a formula that will give you the period of an object that is undergoing simple harmonic motion.

3. a) Derive a formula that will enable you to determine the restoring force acting on the bob of a pendulum.

   b) Consider the following diagram:

   1. If the mass of the ball at the end of the pendulum is 20 kg, what is the magnitude of the linear restoring force acting on it when it is at the top of its arc?
   2. What is the period of the pendulum?

4. Is centrifugal force a fictitious force? Justify your answer.

BIBLIOGRAPHY

I. Books:

1. Physical Science Study Committee, Physics, 2nd edition (D. C. Heath and Co., 1965).

2. Taffel, Physics, Its Methods and Meanings (Allyn and Bacon, Inc., 1965).

3. Williams, Metcalfe, Trinklein, Lefler, Modern Physics (Holt, Rinehart, and Winston, Inc., 1968).

II. Lab Manuals:

1. Physical Science Study Committee, Physics Laboratory Guide, 2nd edition (D. C. Heath and Co., 1965).

2. Taffel, Physics, Its Methods and Meanings Laboratory Manual (Allyn and Bacon, Inc., 1965).

III. Filmstrips:

1. Force and Motion (McGraw Hill Book Company)

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RATIONALE

In the previous LAP we studied the dynamics of motion. What causes an object to change direction, or to accelerate, or to stop. We studied the types of forces that cause such behavior.

In this LAP we will concern ourselves primarily with three things: momentum, work, and energy. We will determine why a car does more damage than a baseball when they hit an object even if they are traveling at the same speed. We will learn what is meant by work and various ways in which work is performed. FInally, we will study energy and see why we say that it is the ability of an object to do work.

Behavioral Objectives

By the completion of the prescribed course of study you will be able to:

1. Define impulse of a force and work problems relating to this definition.

2. Define momentum of a body and work problems relating to this definition.

3. Demonstrate your understanding of conservation of momentum by:
   a. Writing a one-page paper describing experiments that have been performed to demonstrate that momentum is conserved.
   b. Working problems relating to conservation of momentum in the interaction of several bodies.

4. Define the center of mass of two interacting bodies and work problems relating to this definition.

5. Demonstrate your understanding of the relationship between conservation of momentum and velocity of center of mass by being able to derive a formula showing this relationship.

6. Demonstrate your understanding of rocket propulsion by stating a formula involving the total mass of a rocket, the mass is ejected, and the change in velocity of the rocket and working problems relating to this formula.

SECTION I

Resources

1. Readings:
    1. PSSC - #1 pps. 378-379; #2 pps. 380-381; #3 pps. 381-387; #4 pps. 387-388; #5 pps. 388-391; #6 pps. 393-396.
    2. Taffel - #1, #2 pps. 113-114; #3 pps. 114-116; #4, #5, #6 ____.
    3. Williams - #1 - #3 pps. 90-92; #4, #5, #6, ____.

2. Problems:
    1. PSSC - #1, p. 397 ex. 1-7; #2 pps. 397-398 ex. 8, 10-13; #3, pps. 398-399 ex. 13-14, 16-18, 26; #4 pps. 399-400 ex. 21-22, 24, 27-28; #5 ____; #6 p. 398 ex. 20.
    2. Taffel - #1, #2 pps. 117-118 ex. 1 (1,2), 2 (5,6) 1(1-3) 2(8-9); #3 pp. 117-119 ex. 1(3-4), 2(6-8) 1(4,6-7), 2(10-11); #4, #5, #6 ____.
    3. Williams - #1-#3 pps. 92-93 B(16-17), B(12-14, 16); #4, #5, #6, ____.

3. Laboratories:
    1. Physics, Its Methods and Meanings: Lab 14
    2. Physics, Its Methods and Meanings: Lab 15
    3. Physics: Lab III - 7
    4. Physics: Lab III - 8

SELF-EVALUATION I

1. An 1800kg. car increases its speed at a uniform rate in a straight line from 15 m/sec to 30 m/sec in 7 sec.

   (a) What impulse acted on this car?

   (b) What force produced this acceleration?

2. A motorcycle traveling at 7 m/sec increases its speed to 18 m/sec in 10 sec.

   (a) What was the initial momentum of this motorcycle?

   (b) What was the final momentum of this motorcycle?

   (c) What impulse acted on this motorcycle?

   (d) What was the magnitude of the force acting on this motorcycle?

3. A bomb having a mass of 100 kg. explodes in the air into two pieces that fly out vertically in opposite directions from one another. If the mass of one piece is 33 kg and the mass of the other piece is 67 kg, what is the ratio of the velocity of the first piece to the velocity of the second piece?

4. a. Define center of mass.

   b. A 5 kg ball is moving towards a 20 kg ball at rest with a speed of 3 m/sec.

      1) If the balls are 72 m apart, how far is the center of mass from each ball?

      2) What is the velocity of the center of mass?

5. Derive a formula that demonstrates the relationship between conservation of momentum and center of mass.

6. If a rocket of mass 5 kg ejects 100 g of fuel through the exhaust nozzle with a speed of 100 m/sec, what is the change in velocity of the rocket?

ADVANCED STUDY 1

1. Write a three page report on Kepler's three laws of planetary orbits. Your report should include diagrams and tables of data to illustrate each of these three laws.

2. Write a three page paper explaining three different theories concerning the structure of our solar system.

3. Write a paper explaining the Law of Universal Gravitation. Your paper should include a statement of the law, a mathematical derivation of this law, laboratory tests of the law, and some applications of the law.

Behavioral Objectives

By the completion of the prescribed course of study, you will be able to:

1. Define work and work problems relating to this definition.
2. Demonstrate your understanding of kinetic energy by deriving a formula that will enable you to calculate the kinetic energy of a body and work problems relating to this formula.
3. Demonstrate your understanding of the change in kinetic energy that occurs when two bodies interact and the force of interaction is a constant repulsive force by:
   a. deriving a formula that shows this relationship and working problems relating to this formula.
   b. presenting a one-quarter page argument that shows the total kinetic energy changes during the interaction but is the same after the interaction as it was before the interaction.
   c. deriving a formula that shows this transfer of kinetic energy relative to the center of mass of the two bodies and working problems relating to this formula.
   d. deriving formulas that will give the velocities of the bodies after the interaction and working problems relating to these formulas.

RESOURCES

1. **Readings:**
   1. PSSC - #1 pps. 402-406; #2 pps. 406-407; #3 pps. 407-417.
   2. Taffel - #1 pps. 136-137; #2 pps. 155-156; #3 pps. 156-157.
   3. Williams - #1 pps. 124-126; #2 pps. 131-132; #3 ____.
2. **Problems:**
   1. PSSC - #1 p. 418 ex. 2-5; #2 pps. 418-419 ex. 6-11, 13;
      #3 pps 419-421 ex. 15-16, 18-25, 28-31.
   2. Taffel - #1 pps. 146-148 ex. 1(2), 2(9), 1(1-2,4) 2(12,13,15);
      #2 pps. 168-170 ex. 1(1-2), 2(11-14), 1(1,6), 2(15);
      #3 pps. 169-170 ex. 1(8), 2(15, 2(17-18, 22)
   3. Williams - #1 pps. 129-130 A (1-4), A(1-2,4), B(9,11-12)
      #2 pps. 135-136 ex. B(7), A(3-4), B(8-9); #3 ____.

1. a. Define work.

   b. A force of 25 nt is directed towards a dry ice puck at an an angle of 60° with the horizontal and moves the puck 5 m. How much work is done by this force?

2. What is the kinetic energy of a proton (mass = 1.7×10^{-27}kg) When it is moving at a speed of 3.5×10^{8} m/sec?

3. Derive a formula that shows the total change in kinetic energy that occurs when two objects interact and the force of interaction is a constant repulsive force depends on the magnitude of the force and the change in separation of the objects.

4. A ball of mass 5 kg is moving towards a ball with mass 25 kg which is at rest at a speed of 20 m/sec.

   a) What are the initial kinetic energies of both bodies?

   b) What are the velocities of each mass after the collision?

   c) What are the final kinetic energies of both bodies?

1. A set of pulleys with an ideal MA of 12 is used to raise a 240 lb safe a height of 6 ft.

   a. Draw a diagram of the set of pulleys.

   b. If there is no frictional loss, what effort must be applied?

   c. How much cord will be pulled in by the effort?

   d. What is the work input?

   e. What is the work output?

2. A wheel and axle whose radii are 1 m and .25 m respectively is used to lift a wieght of 50 nt.

   a. Assuming it is an ideal machine, what effort will be required to operate it?

   b. If the effort really needed is 17.5 nt, how much force is used to overcome friction?

   c. What distance must the effort move to raise the weight 8 m?

   d. What is the owrk output?

   e. What is the work input?

3. A 9 ft. board is used to make an inclined plane to roll a barrel to a platform 3 ft. above the floor.

   a. How much work would be required to raise the barrel directly from the floor to the platform?

   b. If friction is neglected, what effort would be required to roll the barrell up the incline?

SECTION 3

Behavioral Objectives

By the completion of the prescribed course of study, you will be able to:

1. State a formula that will enable you to determine the total energy in an interaction between a mass and a spring bumper and work problems relating to this formula.

2. Demonstrate your understanding of the gravitational potential energy and kinetic energy of a body that is suspended at height h above the earth by:
   a. deriving a formula that will enable you to determine the gravitational potential energy of a body at height h.
   b. stating a formula that shows the relationship between these two energies in terms of the total energy of the system and working problems relating to this formula.

3. Demonstrate your understanding of gravitational potential energy for an object at any separation r from the earth by deriving a formula that will enable you to determine the gravitational potential energy of this object and working problems relating to this formula.

4. Demonstrate your understanding of the forces required to put an object in orbit around the earth or to free it from the earth's gravitational pull by being able to:
   a. determine the escape kinetic energy of any given object on the earth's surface.
   b. derive a numerical value for the escape velocity of any object from the surface of the earth.
   c. determine the binding energy of any given object to any other given object.

Resources

1. **Readings:**
   1. PSSC - #1 pps. 422-426; #2 pps. 426-433; #3 pps. 433-434; #4 pps. 434-437.
   2. Taffel - #1 ____; #2 pps. 157-161; #3 pps. 161-162; #4 pps. 162-164.
   3. Williams - #1 ____; #2 pps. 130-131; #3 ____; #4 ____.
2. **Problems:**
   1. PSSC - #1 pps. 438-439 ex. 1-5, 7-8, 14-16, 19; #2 pps. 441-442 ex. 20-21; #3 p. 442 ex. 22-23; #4 p. 442 ex. 24-26, 28-30.
   2. Taffel - #1 ____; #2 pps. 169-170 ex. 1(3,7,9), 1(7-10, 13-14), 2(16,21); #3 p. 170 1(11); #4 p. 170 1(11).
   3. Williams - #1 ____; #2 pps. 135 - 136 ex. A(1-2), A(1-2), B(7); #3 & #4 ____.
3. **Laboratories:**
   1. Physics: Its Methods and Meanings, Lab 19
   2. Physics: Lab III - 12
   3. Physics: Lab III - 13

SELF-EVALUATION 3

1. A mass of 1.5×10^3 kg sliding with a speed of 2.4×10^{-2} m/sec on a frictionless surface collides with a spring bumber which has a force constant of 135 nt/m.

   a. What is the kinetic energy before the collision?

   b. What is the maximum compression of the spring?

   c. What is the potential energy when the spring is compressed one-quarter of the way?

2. An object is suspended 25 m above the earth. What will be the kinetic energy and gravitational potential energy of the object when it drops 20 m?

3. What is the gravitational potential energy of an object that is 1.8×10^5 m above the surface of the earth if the radius of the earth is 6.37×10^6 m and the mass of the earth is 5.98×10^{24} kg?

4. What is the binding energy of a 1200 kg satellite to the earth?

BIBLIOGRAPHY

I. Books:

1. Physical Science Study Committee - Physics, Second Edition (D. C. Heath and Co., 1965).
2. Taffel - Physics, Its Methods and Meanings (Allyn and Bacon, Inc., 1965).
3. Williams, Metcalfe, Trinklein, Lefler - Modern Physics, (Holt, Rinehart, and Winston, 1968).

II. Laboratory Manuals:

1. Taffel - Physics, Its Methods and Meanings Laboratory Manual, (Allyn and Bacon, Inc., 1965).
2. Physical Science Study Committee - Physics Laboratory Guide, (D. C. Heath and Co., 1965).